# What is Power Factor ?

The power factor of an AC electric power system is defined as the ratio of the real power flowing to the load to the apparent power, and is a dimensionless number between 0 and 1 (frequently expressed as a percentage, e.g. 0.5 pf = 50% pf).

Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power.

Engineers use the following terms to describe energy flow in a system (and assign each of them a different unit to differentiate between them):
• Real power (P) — watt [W]
• Reactive power (Q) — volt-amperes reactive [var]
• Complex power (S) — volt-ampere [VA]
• Apparent Power (|S|), that is, the absolute value of complex power S — volt-ampere [VA]
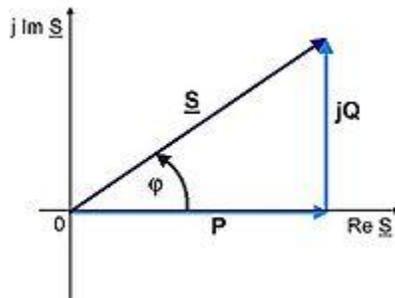
In the diagram, P is the real power, Q is the reactive power (in this case positive), S is the complex power and the length of S is the apparent power.

Power Factor = Real Power / Apparent Power.

It's a practical measure of the efficiency of a power distribution system. For two systems

transmitting the same amount of real power, the system with the lower power factor will have higher circulating currents due to energy that returns to the source from energy storage in the load. These higher currents produce higher losses and reduce overall transmission efficiency. A lower power factor circuit will have a higher apparent power and higher losses for the same amount of real power.

The power factor is one when the voltage and current are in phase. It is zero when the current leads or lags the voltage by 90 degrees. Power factors are usually stated as "leading" or "lagging" to show the sign of the phase angle, where leading indicates a negative sign.

Purely capacitive circuits cause reactive power with the current waveform leading the voltage wave by 90 degrees, while purely inductive circuits cause reactive power with the current waveform lagging the voltage waveform by 90 degrees. The result of this is that capacitive and inductive circuit elements tend to cancel each other out.

Where the waveforms are purely sinusoidal, the power factor is the cosine of the phase angle (φ) between the current and voltage sinusoid waveforms. Equipment data sheets and nameplates often will abbreviate power factor as "cosφ" for this reason.

Example: The real power is 700 W and the phase angle between voltage and current is 45.6°. The power factor is cos(45.6°) = 0.700. The apparent power is then: 700 W / cos(45.6°) = 1000 VA.

Linear loads with low power factor (such as induction motors) can be corrected with a passive network of capacitors or inductors. Non-linear loads, such as rectifiers, distort the current drawn from the system. In such cases, active or passive power factor

correction may be used to counteract the distortion and raise power factor. The devices for correction of power factor may be at a central substation, spread out over a distribution system, or built into power-consuming equipment.